

## **SHOE SUSPENSION SYSTEM**

This application is a non-provisional of prior U.S provisional appln. nos. 60/427,959, filed November 21, 2002, and 60/491,260, filed July 31, 2003. The entire contents of both applications are hereby incorporated by reference.

### **EXPLANATION OF THE "Shoe Suspension System" INVENTION**

The spring shoe inventions here proposed relate to eight different models that have unique applications. Model 1 is a low cost walking/running shoe. Model 2 is a high performance running shoe for straight line running. Model 3 is a high performance cross trainer. Model 4 is an ultra-high performance cross trainer. Model 5 is a high-speed, straight-line running boot. Model 6 is a high performance agility boot. Model 7 is an ultra-high performance agility boot. Model 8 is a stable, ultra high-speed boot with moderate agility. Models are distinguished by different compression lengths and different innovation combinations. Model 1 has a relatively short compression length. Models 2, 3 and 4 have a short to moderate compression length. Models 5, 6 and 7 have a relatively long compression length. Model 8 has a very long

compression length. Models 1, 2 and 5 employ a lower mid-sole that remains on plane with the upper sole. Models 3, 4, 6, 7 and 8 employ a laterally pivoting Lower Mid-sole. The springs on Models 1, 2, 3, 5 and 6 store forces less than or somewhat similar to the user's bodyweight. Models 4, 7 and 8 use pressure sensors, microprocessors, levers, ratchet wheels and solenoids to store and release multiples of the user's bodyweight.

List of structures for all models:

- A) Primary Tandem Hinges
- B) Primary Connecting Rods
- C) Primary Opposing Tandem Hinges (Models 2a, 3a, 3c, 4, 5, 6, & 7) / Horizontal Guide Tubes and Rods (Model 2b, 2b, 3b & 3c) / Telescoping Vertical Guide Tube and Rod (Model 8)
- D) Upper Mid/Heel-sole
- E) Lower Toe-sole
- F) Lower Mid-sole
- G) Lower Heel-sole
- H) Secondary Tandem Hinge
- I) Secondary Connecting Rod
- J) Upper Toe-sole

- K) Tread
- L) Stopper
- M) Cable
- N) Hinge
- O) Screen
- P) Flex Point
- Q) Flexible Section of Lower Sole
- R) Rivet
- S) Torsion Spring
- T) Lateral Support Pillar
- U) Heel Torsion Spring
- V) Rubber Spring
- W) Independent Torsion Spring Hinge
- AR) Arm
- AS) Ankle Support
- AKS) Ankle/Knee Support
- BJ) Ball Joint
- BP) Battery Pack
- BR) Bumper
- CF) Carbon Fiber Spring
- CS) Coil Spring
- HI) Carbon Fiber Toe Spring (option to H/I)
- IV) Inlet Valve
- KK) Dirt Tread (option to K)

LV) Lever  
MP) Microprocessor  
OO) Side Wall  
OV) Outlet Valve  
PS) Pressure Sensor  
RL) Relay  
RW) Ratchet Wheel  
SN) Solenoid  
WC) Winding Cable  
WR) Wire

**Detailed Description of Parts, Grouped by Function:**

Function 1: A parallel upper sole and lower sole wherein the lower sole extends from the upper sole in a perpendicular or nearly perpendicular (in the case of Model 1) direction, permitting users: 1) optimum control, safety, and agility, 2) energy transfer from the heel to the ball of the foot, and 3) natural walking and running motion.

A) Primary Tandem Hinges or Struts (model 2d)

For Models 3, 4, 6, 7 & 8, the lower arm of the hinge narrows to allow for lateral pivot of the lower mid-sole. For all models, these structures attach the Upper

Mid/Heel Sole and the Lower Mid-sole. Model 1 has a "Z" type design wherein the hinge axis is attached directly to the upper sole. Models 2a, 3a, and 4 through 8 possess a ">" design. Models 2b, 2b and 3b have an "X" type design and Model 3c has a "y" type design. Further R & D may reveal that a ">< <>", an "X" or a "y" design is more efficient for all models. In all Models, these hinges should be light and inflexible in their construction (e.g. steel or alloy) but should be able to rotate freely. The purpose of these structures is to: 1) Attach the Upper Mid/Heel Sole and the Lower Mid-sole, 2) Resist lateral movement of the lower sole, 3) Allow for extension of the Lower Mid-sole in a direction perpendicular to the Upper Mid/Heel-sole, 4) Provide two congruent lever arms and therefore congruent swing angles, 5) Provide attachment points for the Primary Connecting Rods, Horizontal and Vertical Guide Tubes and Rods, and 6) Provide a structure for energy storage (i.e. carbon fiber springs or housing for torsion springs).

The ideal maximum opening angle is dependant upon the force curve analysis and application.

#### B) Primary Connecting Rods

This structure is contained in Models 2a, 2c, 2d, 3a, 3c, 4, 5, 6, 7 & 8. It is long and relatively thin and may be solid or hollow. This structure must be made of light and rigid material so as to resist compression, expansion or failure (e.g. steel or alloy). This structure connects the two Tandem Hinges or Struts. The purpose of this structure is to: 1) maintain equal distance between the Tandem Hinges thereby ensuring that the upper and lower mid-sole remain parallel throughout compression, and 2) couple the Tandem Hinges, thereby providing additional resistance to twisting forces on either Tandem Hinge.

C) Primary Opposing Tandem Hinges with Connecting Rod Coupling Tube (Models 2a, 2b, 2c, 3a, 4, 5, 6, & 7) / Horizontal Guide Tubes and Rods (Model 2b, 3b & 3c) / Telescoping Vertical Guide Tubes and Rods (Model 8) / Primary Opposing Tandem Struts with Connecting Rod Coupling Tube (Model 2d)

The Primary Opposing Tandem Hinge is a structure similar in height to the Primary Tandem Hinges but is slightly narrower. It is attached to the underside of the Upper Mid/Heel-sole and the topside of the Lower Mid-sole. There it compresses and expands in conjunction

with the Primary Tandem Hinges. Like the Primary Tandem Hinges this structure is coupled by Primary Connecting Rods.

The Horizontal Guide Tubes and Rods are an extension of the Tandem Hinges and therefore would be of the same proportions and material. This structure is attached to the underside of and parallel to the Upper Mid/Heel-sole. The length of Tubes and Rods and the fit between them must be such that there is no deflection in the guide-path, during compression or expansion. A friction reducing liquid (e.g. oil or grease) may be added to insure smooth operation.

The Telescoping Vertical Guide Tubes and Rods are found in Model 8 but could also be used on Models 5, 6 and 7. This structure consists of a Rod attached to the Lower Mid-sole, via a triangular shaped part and to the Upper Mid/Heel-sole via one or two sleeved tubes. The top Tube is mounted on the side of the shoe upper and up to the boot hinge. The cross-section of the Tubes and Rods are oval. The length of Tubes and Rods and the fit between them must be such that there is no deflection in the guide-path, during compression or expansion. A friction reducing material (e.g. oil or grease) may be added to insure smooth operation.

Primary Opposing Tandem Struts with Connecting Rod Coupling Tube (Model 2d) is very similar to Primary Opposing Tandem Hinges except that the use struts to maintain a parallel posture in only one (longitudinal) direction. Used in conjunction with this structure is a similar structure, one placed perpendicular across the fore foot and another placed across the heel. From the top view this forms an "I" shaped set of struts and connecting rods that in combination prevent lateral, longitudinal movement as well as maintaining a parallel posture between the upper mid/heel sole and the lower mid/heel sole. A friction reducing material (e.g. oil or grease) may be added to insure smooth operation.

These structures must be constructed of light and rigid material (e.g. steel or alloy) so as to resist deformation. The purpose of these structures is to: 1) maintain a perpendicular compression and expansion of the Upper Mid/Heel Sole and the Lower Mid-sole and 2) provide additional resistance to twisting forces on the lower mid-sole.

#### D) Upper Mid/Heel Sole

This Structure is an extension of the Upper Toe-sole and integral to the leather shoe upper. Its thickness is

relatively little and is shaped to conform to the profile of the foot, not including the toes. It is resistant to lateral and longitudinal bending, compression and expansion and can be constructed with a stiffening brace to achieve this. It should be constructed of a light and inflexible material (e.g. steel, carbon fiber). The purpose of this structure is to: 1) Support the ball, arch and heel of the foot, 2) Provide an anchor point for the Primary Tandem Hinges and the Primary Opposing Tandem Hinges/Horizontal Guide Tubes.

Function 2: Three lower sole designs patterned after the anatomy of the foot and ankle allowing users optimum traction, stability, control and safety. The first specifies an integrated toe sole, rigid inner mid-sole, flexible outer mid-sole and heel-sole providing mild lateral roll capability. The second contains a separate toe sole, mid-sole and heel sole with a longitudinal hinge connecting it to the Tandem Hinges. The third design illustrates a rod connected at the ends to Lower Toe and Heel Soles via front and rear ball joints. These last two structures allow pivoting the heel or the toe 360 degrees.

E) Lower Toe-sole

For Models 1, 2a, 2b, 2c, 2d and 5, the lower toe-sole consists of an extension of the lower mid-sole. This structure should be flexible and strong (e.g. fiberglass and/or carbon fiber) and somewhat resistant to bending forces (but flexible enough to allow natural roll of the foot during stride.) For Models 3a, 3b, 3c, 4, 6, 7 and 8, the lower toe-sole consists of a circular pad that is hinged from its center, to the fore-edge of the Lower Mid-sole. This structure should be inflexible and strong (e.g. steel or alloy). Both manifestations of the Lower Toe-sole have Secondary Tandem Hinges connected to the topside of their fore sections and have Tread attached to the underside. The purpose of this structure is to: 1) provide traction to the user during step-off, 2) enhance balance and stability during step-off, 3) allow normal use and movement of the toe for greater comfort and, 4) to keep the stride movements natural both during longitudinal and lateral directions.

#### F) Lower Mid-sole

For Models 1, 2a, 2b, 2c, 2d and 5, the Lower Mid-sole consists of an inflexible (e.g. steel, reinforced carbon fiber, or hard plastic), rectangular plate with a flexible extension (e.g. fiberglass or carbon fiber)

filling out the foot-profile-shaped lower sole. This structure is connected to the Tandem Hinges and either the Primary Opposing Tandem Hinge or the Horizontal Guide Tubes and Rods or the Telescoping Vertical Guide Tubes and Rods (Model 8). The purpose of this structure is to: 1) provide traction to the user during mid-stride, and 2) enhance balance and stability during mid-stride in a straight-line run and 3) to help prevent ankle sprains. For Models 3a, 3b, 3c, 4, 6, 7 and 8, the Lower Mid-Sole consists of an inflexible (e.g. steel), rectangular plate. This structure is connected to the Tandem Hinges by a longitudinal hinge thereby allowing a lateral pivot of the upper sole. A Lateral Support Pillar is also inserted between the Lower Mid-sole and the Tandem Hinge arm's hinge pin. For models 6, 7 & 8 an alternative structure can be used comprising of an inflexible rod connected at the ends to Lower Toe and Heel Soles via front and rear ball joints (see model 8 detail). This alternate structure also specifies a Coil Spring above the Ball Joint. The purpose of these structures is to: 1) provide traction to the user during mid-stride and 2) enhance balance and stability during mid-stride in a straight-line or in a turn. All three manifestations of

the Lower Mid-sole call for a tread to be attached to the underside.

#### G) Lower Heel-sole

For Models 1, 2a, 2b, 2c, 2d and 5, the Lower Heel-sole consists of an extension of the lower mid-sole. This structure should be flexible and strong (e.g. fiberglass and/or carbon fiber) and somewhat resistant to bending forces. For Models 3a, 3b, 3c, 4, 6, 7 and 8, the Lower Heel-sole consists of a circular pad that is hinged from its center, to the aft-edge of the Lower Mid-sole. This structure should be inflexible and strong (e.g. steel or alloy). Both manifestations of the Lower Heel-sole have Tread attached to the underside. The purpose of this structure is to: 1) provide traction to the user during heel-strike, and 2) enhance balance and stability during heel-strike.

#### Q) Flexible Section of Lower Sole

This structure relates to lower soles designed not to pivot (Models 1, 2 and 5). It is an extension of the central, rigid rectangle where the Tandem Hinges are attached. It is made of a moderately flexible yet durable material (e.g. fiberglass, carbon fiber). Its

purpose is to allow a user some lateral and rolling movement with their feet on Models without the pivoting lower sole, without a loss in stability and traction.

#### T) Lateral Support Pillar

This part is very similar in size, shape and material to the Stopper. Its placement and function are entirely different however. On Models 3, 4, 6 and 7, the Lateral Support Pillar is placed between the Lower Mid-sole and the Tandem Hinge arm's hinge pin. The purpose of this part is to: 1) resist lateral pivoting of the upper soles, thereby increasing stability and reducing injury, and in some models, 2) provide resistance for the Lower Heel-sole to flex, keeping it in-line with the Lower Mid-sole when not stressed, thereby increasing the user's balance and allowing for smooth operation of the shoe during heel-strike.

#### BJ/CS) Ball Joint with Integral Coil Spring

The Ball Joint with integral Coil Spring is located on Model 8. The structure is defined by a raised circular plateau in the center of the Lower Toe and Heel sole. A ball socket is positioned in the center of this plateau. Extending down in a perpendicular direction from the

Lower Mid-sole rod is an arm with a ball on the end. Located at the top of the arm is a fixed collar, positioned parallel to the Lower Mid-sole rod. A Coil Spring is placed between the collar and the Lower Toe/Heel sole. The purpose of this structure is to: 1) Allow the Lower Toe and Heel soles to pivot 360 degrees, thus increasing lateral movement and overall agility, 2) Provide pivoting resistance to the Lower Toe and Heel soles, thereby increasing stability and safety, 3) Simplify and lighten the shoes compared with other structures.

#### K) Tread

This structure's footprint is the same as that of the Lower Toe/Mid/Heel sole(s). It is relatively thin and its thickness is dependant on how it is attached. This material is similar to the rubber compound found on automobile tires and is very durable and resilient. It is attached to the bottom side of the Toe/Mid/Heel sole(s). The purpose of this structure is to provide traction to the user during walking and running on hard surfaces.

#### KK) Dirt Tread

This structure, which is an option to (K), possesses a footprint larger than that of the Lower Toe/Mid/Heel sole(s). It ranges in thickness between 0.25 and 0.5 inches. The structure is given approximately two holes per square inch and the underside is patterned with cleats. This material is very light and durable (e.g. plastic or composite). It is attached to the bottom side of the Toe/Mid/Heel sole(s). The purpose of this structure is to provide traction to the user during walking and running on rough, soft or sandy surfaces.

Function 3: A structure that maintains a longitudinally parallel posture between the Upper and Lower Toe-sole on Models 1 - 4, during mid-stride compression, forward roll and toe-sole lift off, thereby allowing users optimum balance, control, traction and safety.

#### H) Secondary Tandem Hinges

This structure specifies two parallel hinges with arms connected to the Upper and Lower Toe Soles. These hinges should be light, strong and inflexible (e.g. steel). The purpose of this structure is to: 1) Allow for extension of the lower toe-sole in a direction perpendicular from the Upper Toe-sole, 2) provide two congruent lever arms

and therefore congruent swing angles and 3) provide attachment points for the Secondary Connecting Rods.

#### I) Secondary Connecting Rods

This structure is attached to the sides of the Secondary Tandem Hinges. The length of these parts coincides with the distance between the Secondary Tandem Hinges' mounting points. This structure must be made of light and rigid material so as to resist compression, expansion or failure (e.g. steel or alloy). The purpose of this structure is to maintain equal distance between the Tandem Hinges, thereby ensuring that the Upper and Lower Toe-sole remain parallel throughout compression and expansion, thus allowing users optimum balance, control, traction and safety.

#### J) Upper Toe Sole

This structure is an extension of the Upper Mid/Heel-sole and integral to the leather shoe upper. Although it is resistant to lateral twisting (e.g. fiberglass, carbon fiber), it is flexible across the ball joint of the foot to allow bending with the users toes. Attached to the underside is the Secondary Tandem Hinges. The purpose of this structure is to: 1) support the balls and toes of

the foot, 2) allow natural bend of the toes during stride and 3) provide an anchor point for the Secondary Tandem Hinges

#### HI) Carbon Fiber Toe Spring

This structure is a more simple and inexpensive option to H/I and would be most likely employed on Model 1, 5 - 7, if at all. It protrudes from the underside of the Upper Toe-sole at a length comparable to the distance between the Upper Mid/Heel-sole and the Lower Mid-sole when fully compressed. It is placed at the tip of the toe and curved toward the heel. Using this structure, it is necessary to construct the Upper Toe-sole such that it cannot flex below the plane of the Upper Mid/Heel-sole. The purpose of this structure is to: 1) Connect the Upper Toe-sole and the Lower Toe-sole such that the Upper is supported by the Lower and thus maintain a parallel or nearly parallel position of the Lower Toe-sole, relative to the Upper Toe-sole, thereby increasing a user's control, balance, traction and stability and, 2) Prevent the Upper Toe-sole from rubbing on the walking or running surface during step-off.

#### K) Tread

SEE ABOVE FOR DESCRIPTION

KK) Dirt Tread

SEE ABOVE FOR DESCRIPTION

Function 4: Limit the maximum and minimum opening of the soles while at the same time, softening the impact of the foot as the sole reaches its full compression, thereby increasing control, stability, safety and comfort.

L) Stopper

The Stopper is found on all models in one form or another. In all cases it is a rubber cylinder. As with all rubber, it is more resistant to deformation as it becomes more compressed. Additionally, it is extremely resilient. The Stopper is always found attached to the underside of the Upper Mid/Heel Sole. When the soles are in a closed position, the Stopper is compressed by either the Tandem Hinges or the Lower Mid-sole. The purpose of this structure is to: 1) Soften the impact of the foot as limit is reached and 2) Limit the maximum compression of the Upper Mid/Heel Sole with the Lower Mid-sole, thus preventing deflection of and/or variance between the

Primary Tandem Hinges and the Upper and Lower Mid-soles  
(for Model 1 only).

M) Cable

The Cable is found on all models except Model 1. This structure is a high strength thread or string (e.g. braided steel, carbon fiber, synthetic microfilament). It is attached to the underside of the Upper Mid/Heel Sole and the topside of the Lower Mid-sole or thereabouts. Its purpose is to limit the maximum distance between the Upper Mid/Heel Sole and the Lower Mid-sole.

Function 5: A light and compact structure to store and release energy spent during walking and running. For maximum benefit a unique combination of these springs is necessary for walking, running, and jumping. Figure 1 shows how the force curve varies from spring structure to spring structure and how in combination, they can obtain a flat or modified-flat force curve.

S) Torsion Spring

The Torsion Spring is a spring constructed of spring steel. It is integrated into the Tandem Hinges or the

Independent Torsion Spring Hinge (Model 2a) and may be pre-loaded. The arm length coincides with the length of the Tandem Hinge's arms of which it is housed. The number of Torsion Springs per shoe and the thickness of the wire used are based upon the user's weight or leg-strength, depending on the model. Therefore, each shoe will be tailored to the user's weight or leg-strength as well as their foot size. The purpose of this structure is to efficiently store and release energy spent during walking and running in a compact package so as to return maximum impact absorption and walking/running performance.

#### U) Heel Torsion Spring

The Heel Torsion Spring is a spring constructed of spring steel. This structure is attached to the topside of the Lower Mid-Sole and the Lower Heel-Sole where they meet. The arm length and thickness are dependent upon the shoe size and user's weight. The purpose of this structure is to efficiently absorb energy during heel strike while at the same time allowing for maximum traction.

#### V) Rubber Spring

The Rubber Spring is an elastic polymer that spans the distance between the hinge joints of the two opposing hinges and is a potential option to steel coil compression springs. The size of this structure is dependent upon the forces that it will store which is dependent upon the application and weight and strength of the user. The purpose of this structure is to store energy and release it at an accelerating rate

#### W) Independent Torsion Spring Hinge

This structure is employed on Model 2a but could be used on Model 3a as well. It is very similar in design to the Tandem Hinges but stands independent of the other structures in the sole. Its purpose is to house Torsion Springs so as to supplement the spring forces generated by the Tandem and Opposing Tandem Hinges.

#### CF) Carbon Fiber Spring

The Carbon Fiber Spring is an option to the Torsion Spring and may be preferred in any model if it can be shown to be lighter and more durable. It is constructed of carbon fiber of varying width and thickness. The shape of this structure is symmetrical with two concave curves, tapering towards the ends and joined at the ends

with a flexible polymer. This shape is designed to allow significant compression of the spring without overstressing any section. The purpose of this structure is to efficiently store and release energy spent during walking and running in a compact package so as to return maximum impact absorption and walking/running performance.

Function 6: For models in which the compressed spring load significantly exceeds a user's body weight (i.e. Models 4, 7 and 8), a system to hold and release ("HRS") the energy stored in the springs at an optimum time during accelerating, cruising or while decelerating. Utilizing this system, the performance benefit is roughly proportionate to the stored energy loads in excess of the user's body weight. Thus, this structure allows users to more than double their running stride and jumping performance compared to similar models without this system. This system is optimally designed in that it delivers: 1) Excellent control, 2) High running and jumping performance, 3) Safe deceleration/stopping, 4) A greater measure of running efficiency, allowing users to run longer distances while burning the same calories, 5) A completely natural running motion, which in-turn, further increases stability, reduces fatigue, and further increases

performance and 6) A safety default to disengage system if mechanical failure occurs.

The components necessary to enable this system are:

Pressure Sensor, Microprocessor, Relay, Battery Pack, Solenoid, Lever, Ratchet Wheel, Winding Cable, Wire and Coil Spring. As a user runs, the shoe's sole is compressed. During this process, the Winding Cable is gathered and wound by the Ratchet Wheel. At the same time, the Pressure Sensors send signals to the Microprocessor via wire, which determines the timing of holding and releasing the stored energy. At the appropriate times, it sends a signal via wire, to the Relay. The Relay then activates, via wire, the Solenoid which is powered, also via wire, by the Battery Pack. The Solenoid then first pulls the Arm and Lever, thereby stopping the Ratchet Wheel from rotating and holding the compression of the sole. Then subsequently, the Solenoid releases the Arm and Lever which is pulled back by the Coil Spring, thereby liberating the Ratchet Wheel to rotate. This in turn, releases the winding cable and allows expansion of the sole.

PS) Pressure Sensor

This structure is approximately 1 inch in diameter and relatively thin. It is positioned in the center topside of the ball and heel pad within the shoe upper. It has a wire attached to it sending the electronic signal to the Microprocessor. The purpose of this structure is to measure the loads that the user imparts on the ball and heels of his or her feet.

WR) Wire

This structure is approximately six inches long and relatively thin. It is made of copper and coated with rubber or plastic. It attaches the Pressure Sensors to the Microprocessor, the Microprocessor to the Relay, the Battery Pack to the Relay and the Relay to the Solenoid. The purpose of this structure is to relay electronic signals between these components.

MP) Microprocessor

This structure is relatively small so as to fit between the upper and lower sole. It consists of a simple computer processor chip, a small battery and an input and output line. It is connected to the Pressure Sensors and the Relay Switch by Wire. The purpose of this structure is to process the loads detected by the Pressure Sensors,

then calculate the timing of the catch and release and finally send signals accordingly to the Relay.

The protocol for timing the energy hold and release for accelerating or constant-speed running and decelerating or stopping is as follows:

The Microprocessor first determines whether the user is accelerating/maintaining running speed or decelerating/stopping. During accelerating/constant-speed running, heel-strike loads and time duration are fairly consistent with less than 10 percent variation. During decelerating or stopping, however, the heel-strike loads and time duration exceed the prior heel-strike loads and duration by more than 10 percent. Using this program logic and Pressure Sensors, the Microprocessor recognizes the user's mode and responds accordingly. If the user is decelerating or stopping, the Microprocessor does not activate the HRS. If the user is accelerating or maintaining running speed, however, the Microprocessor does activate the HRS by sending a signal to the Relay. This triggers the Solenoid to move the Arm and Lever which in turn allows the Ratchet Wheel to wind until the sole has reached maximum compression in that step. At

this point, these components working together hold compression of the sole until the Microprocessor activates the release. The Microprocessor signals the release when the heel Pressure Sensor detects that the load is diminishing (or zero) and the ball Pressure Sensor detects that the load is in excess of the user's body weight but has begun to diminish. In this way, the user will have a smooth release of stored energy during running only. As a safety precaution, the default for the HRS is disengagement. This insures that if there is a mechanical failure, sole compression will not be held at any time. Therefore, the user's forward energy will be safely converted to vertical energy, allowing the user to safely slow his forward momentum.

#### RL) Relay

The Relay is a small part that can be less than 0.5 cubic inches. It is attached to the underside of the Upper Mid/Heel-sole and is connected to the Microprocessor, Solenoid and Battery Pack, via Wire. Its purpose is to receive signals from the Microprocessor and either open or close the electric current from the Battery Pack.

BP) Battery Pack

The Battery Pack is a part whose dimensions are unknown. It will depend on the power needed to activate the Solenoid, the efficiency of the Lever, and the friction between the Lever and the Ratchet Wheel. If this component can be less than 2 inches by 1 inch by 0.5 inch, then it can be attached to the underside of the Upper Mid/Heel-sole. Otherwise it can be attached to the user's shin or belt. The cover is constructed of a material light and non-conductive (e.g. plastic). It is connected to the Relay, via Wire. The purpose of the Battery Pack is to power the Solenoid, Relay, Microprocessor, and Pressure Sensor.

SN) Solenoid

The Solenoid is a part with dimensions roughly 1 inch cube or less. It is composed of metal components. It is attached to the underside of the Upper Mid/Heel-sole. This part is attached to the Relay via Wire. It is attached to the Lever, via Arm. Its purpose is to pull and release the Arm and therefore Lever.

AR) Arm

The Arm is a part approximately 0.25 inches wide and 2 inches long. It is made of light and rigid material (e.g. steel). It is integral to the Solenoid and is attached to the Lever. Its purpose is to connect the Solenoid to the Lever.

#### LV/CS/BR) Lever with Coil Spring and Bumper

The Lever is a part approximately 1.8 by 0.8 by 0.125 inches and is made of a strong and rigid material (e.g. steel or carbon fiber). It is shaped like a right triangle with two holes at the end of the longer leg and one hole at the end of the shorter leg. The hole at the end of the shorter leg is the mounting point for a pivot axle. The other hole is for mounting the Arm and the Coil Spring. At the right angle is a tooth that fits into the Ratchet Wheel. Although this part is lubricated for free movement, the coil spring pulls the Lever away from the Solenoid and the Ratchet Wheel where it bumps against a Bumper. The Bumper is a steel protrusion from the underside of the Upper Mid/Heel-sole. It is covered with rubber for quiet and smooth operation. The purpose of the Lever is to convert the Solenoid/Arm sliding movement into a catch for the Ratchet Wheel. The purpose of the Coil Spring and Bumper is to keep the Lever from

catching the Ratchet Wheel until it is activated by the Solenoid.

RW) Ratchet Wheel

The Ratchet Wheel is a circular structure approximately 1 inch in diameter and 0.25 inches thick. It has a 0.25 inch diameter hole in the center and teeth protruding from the lower edge approximately 0.125 in thickness. It has a channel in the underside wherein a clock spring is located. This allows the Ratchet Wheel to be self-winding. It is made of a high-strength material (preferably stainless steel). It is attached to the underside of the Upper Mid/Heel-sole by a steel axle. Two Winding Cables are firmly attached to the toothless circumference. Its purpose is to wind the Winding Cables and work in conjunction with the Lever to hold and release the compressed sole. An alternative to this structure could be a spring loaded pin that is connected to the coupled connecting rods.

WC) Winding Cables

The Winding Cables are structures made of very strong material (e.g. braided steel wire or synthetic micro filament (about 500 lbs. test)). One Winding Cable is

connected to the center front edge of the Lower Mid-sole and threads through the center front edge of the Upper Mid/Heel-sole. The other Winding Cable is connected to the center back edge of the Lower Mid-sole and threads in a perpendicular direction to the center of the Upper Mid/Heel-sole. Both Winding Cables are attached to the Ratchet Wheel. The purpose of these components is to hold the compression of the sole.

Function 7: Structures that support the ankle (Models 5, 6 and 7) or the ankle/knee (Model 8) thereby providing optimal safety without compromising comfort and mobility.

#### AS) Ankle Support

The Ankle Support, which is on Models 5, 6 and 7, is made of moderately flexible yet durable material (e.g. plastic). It is approximately eight inches tall, the width of the lower leg and between 0.0625 and 0.25 inches thick. It has a system for tightening the structure around the user's shin (e.g. laces, buckles, Velcro) and is attached to the shoe upper, via a pivot. This pivot can be raised or lowered to match the position of the user's ankle joint. The purpose of this structure is to

prevent the ankle from bending laterally while nonetheless, allowing a natural pivot of the foot.

#### AKS) Ankle/Knee Support

The Ankle/Knee Support, which is on Model 8, consists of two posts, positioned at the side of the lower leg and connected to the shoe upper via a pivot. At the top of these posts hinges, similar to a knee joint, connect a second set of posts positioned at the side of the upper leg. A thigh strap is attached to the top of the upper posts. This structure is made of a strong, rigid and lightweight material (e.g. aluminum or carbon fiber composite) and padded fabric. It is approximately 24 inches tall and as wide as the user's thigh. It is hollow and the walls may be up to 0.25 inches thick. This structure includes a system for tightening around a user's shin and thigh (e.g. laces, buckles, Velcro). The ankle and knee pivot can be raised or lowered to match the anatomy of the user. It is also adjustable in post length between the knee hinge and the thigh strap. The purpose of this structure is to: 1) protect the user's ankle from lateral bending, 2) protect the user's knee from lateral or twisting movements and 3) Allow user's to

move their feet and lower legs in natural or normal manner.

Function 8: A structure that combines a compressible shoe sole air-filled cavity with one-way valves to cool the user's foot.

OO) Side Wall (option to O)

A flexible air-tight, water-tight membrane (e.g. rubber) attached to the bottom edge of the Upper Sole and the top edge of the Lower Sole most likely on Model 1. The purpose of this structure is to: 1) Create a compressible air-filled cavity and 2) Protect the inside structures of the shoe from water and dirt/debris.

IV) Inlet Valves

These simple valves consist of a rubber slit and a rubber membrane attached on one side. These two structures are located on the rearward section of the Side Wall positioned on the right and left of the user's heel, closer to the Upper Sole than the Lower Sole. The purpose of these structures is to allow air to flow into the sole cavity during expansion of the Lower Sole but not out during compression of the Lower Sole.

OV) Outlet Valve

These simple valves consist of a rubber slit and a rubber membrane attached on one side. Four of these seven structures are located in the fore section of the Upper Toe-sole and three in the middle section of the Upper Mid/Heel-sole. The purpose of these structures is to allow air to flow from the sole onto the user's foot during compression of the Lower Sole but not into the sole cavity during its expansion.

Function 9: Use various structures to adequately assemble the invention. These primary structures are the Hinge, the Rivet and the Connecting Rod Cross Brace (Model 2b only).

N) Hinge

Hinges are used in several areas on several models. They are varying diameters and lengths depending on the application and the load. They are made of high strength material (e.g. steel). Their purpose is to allow controlled, low-friction movement of the Lower Sole.

R) Rivet

Rivets are used in several areas on several models. They are varying diameters and lengths and can be steel

or aluminum depending on the load. Their purpose is to attach two structures permanently and inexpensively.

The following parts/structures have varied functions:

O) Screen

The screen is a relatively thin fabric of varying height depending on the model. It is flexible and stretchable but is resistant to tearing. It may be airtight and water-tight but this is not a necessity. It is an effective barrier to dirt and debris. It is attached to the lower edge circumference of the Upper Toe/Mid/Heel-sole and the upper edge circumference of the Lower Toe/Mid/Heel-sole. Its purpose is to: 1) Protect the sole structures from dirt and debris and 2) Hide the inner workings of the shoe for improved appearance and possibly, 3) to protect the sole structures from moisture.

P) Flex Point

The Flex Point is a line where a particular structure is designed to flex.

### **Comparison with Current Art**

Spring shoes thus far have failed in that they have not permitted users to concurrently experience: 1) traction, control, agility and safety comparable to non-spring-loaded footwear, 2) comparable impact absorption and 3) true energy conservation (i.e. storage and return) during walking and running. (The proposed spring shoe structures achieve the above with soles compressing from 0.75 to 11 inches.) Spring shoes that have attempted to address the energy conservation issue have employed either very complex, expensive and unreliable structures or ineffective and imprecise structures. No non-fuel-propelled footwear device has thus far allowed users to increase their maximum running speed. While some have allowed an increase in stride-length, their unnatural use and/or excessive weight prevent users from running any faster than with standard running shoes.

In contrast, all spring shoe models herein described enable users to: increase their running speed, absorb up to 95 percent of heel-strike impact, experience traction, control, agility, and safety comparable to conventional footwear and run and walk using a natural motion. Additionally, users will

enjoy an increased jumping height without compromising safety. Finally, the proposed structure is designed to be simpler and more durable, and/or yield higher performance/control levels than existing energy return shoes

The following patents are noteworthy attempts and will be compared and contrasted to the proposed spring shoe structure.

Patent Number 5,517,769

Spring-Loaded Snap-Type Shoe

This structure attempts to address Function 6 of the proposed structure. It recognizes that a significant increase in performance requires a system to hold the energy loaded during heel-strike and release it during step-off. This structure uses a ratchet to hold the loaded spring and triggers its release by bending the toe section of the shoe. Thus, this system attempts to time the release of energy during step-off.

This design fails in the following ways:

- 1) It provides neither an optimum nor precise timing for energy release. The optimum timing of energy release occurs

immediately following the decrease force during step-off. This system releases the loaded spring when the user bends at the ball of the foot which is not necessarily during and perhaps never at the optimum time. The proposed invention's Function 6's HRS allows for optimum and precise timing of energy release during running.

2) It does not address the proposed invention's Function 1's structure (i.e. parallel upper and lower soles that expand in a perpendicular direction) which is necessary both for control and energy return. The Spring-Loaded Snap-Type Shoe returns energy to the heel alone. This is not ideal because the heel is not in contact with the ground during step-off.

3) It does not address the proposed invention's Function 3's structure (i.e. parallel upper and lower toe soles) which is necessary for traction and control in shoes containing a hollow cavity sole. The Spring-Loaded Snap-Type Shoe requires a hollow cavity extending the length of the foot for the containment of the ratchet and spring system.

Patent Number 4,936,030

Energy Efficient Running Shoe

This structure attempts to address Function 1 and Function 6 of the proposed structure. It recognizes that an increase in performance requires a system to hold the energy loaded during heel-strike and release it from the ball or toe region during step-off. This structure uses a ratchet to hold the loaded spring and triggers its release by bending the toe section of the shoe. This structure also attempts to transfer the forces from the heel to the toe via a series of complex levers and shafts.

This design fails in the following ways:

- 1) It provides neither an optimum nor precise timing for energy release. The optimum timing of energy release is immediately following ball peak-force during step-off. This system releases the loaded spring either: 1) When said spring reaches a certain and fixed degree of compression, 2) When the said spring reaches the limit of compression during push-off or 3) After a fixed time delay. Although the patent neither explains nor diagrams the process by which it accomplishes (2)

or (3), these methods are inadequate and not optimal. The first and third processes are based on fixed criteria and can not adapt to the variable forces and time periods during normal running. The second process is inadequate because it releases the spring prematurely. A user, during a turn or stop may load the forces on his forefoot at constant level before he has picked his final direction. This process therefore, will cause the user to lose control. In contrast, the proposed invention's Function 6's HRS allows for optimum and precise timing of energy release during running.

2) It does not adequately address the proposed invention's Function 1's structure (i.e. parallel upper and lower soles that expand in a perpendicular direction) which is necessary both for control and energy return. The Energy Efficient Running Shoe patent does not guarantee nor does it claim that the ball and heel will compress in a parallel manner. This is because of the number of parts, the complexity of design and the looseness of the system.

3) It does not address the proposed invention's Function 3's structure (i.e. parallel upper and lower toe soles) which is necessary for traction and control in shoes containing a hollow cavity sole.

4) It attempts to achieve its objectives in a complex and therefore expensive and somewhat unreliable way.

This list is not exhaustive.

Patent Number 6,029,374

Shoe and Foot Prosthesis with Bending Beam Spring Structures

This structure attempts to address the simplicity and efficiency of carbon fiber bending beam springs. This structure also attempts to address the need for both heel and toe springs that prevent lateral movement. This structure is inadequate for some of the following reasons: 1) It does not provide a strictly parallel postured upper and lower sole and thus it cannot return more than half the user's weight, 2) It does not provide a parallel upper and lower toe sole and therefore depends on a tapered leaf spring for traction and control which does not provide either in an optimum way, 3) It does not address HRS and therefore limits the combined load forces of the springs to approximately the user's weight.

Device for Helping a Person to Walk

This structure does provide a perpendicularly extending contact patch that extends 10 inches or more below the foot.

This structure is inadequate for some of the following reasons: 1) It does not provide a strictly parallel postured upper and lower sole of normal length nor does it provide a parallel upper and lower toe sole and therefore does not provide adequate balance and control, 2) It does not provide a longitudinally pivoting lower sole and therefore does not allow for adequate agility, 3) It does not address HRS and therefore limits the efficiency of the springs and 4) Each boot weighs approximately 20 pounds (compared to model 8's approximate weight of 10 pounds) which dramatically slows the foot-speed of the user and therefore overall running speed.